As it turned out, the 2-D diffusion code, 2DB, had to be skipped and perturbation theory and kinetics could not be considered.

The next time the course was offered, supplemental manuals were prepared for the codes and the outline was altered by eliminating class 4 and 5 codes and substituting AISITE,[8] a code in the area of reactor siting (a first step away from core orientation). This program was fulfilled more completely but still not entirely. Much of the semester was spent on the cross-section preparation routines with an unsatisfactorily small part being available for important codes like DTF-IV. In addition, there was no possibility to expand shielding or heat transfer-type problems, though job-oriented feedback made it apparent this was desirable. We reasoned that with increasing use of ENDF/B and its associated complex software, the cross-section preparation codes were not representative and decided to eliminate them.

The new course outline became:

1. diffusion theory (1DX)[9]
2. transport theory (DTF-IV)[5]
3. shielding (QUAD-P5A, SPACETRAN)[10,11]
4. siting and environmental (ASITE).[8]

This is the present, but certainly not final, outline. We would very much like to include a safety design code (e.g., CONTEMPT)[12] or a fuel management code, because this is definitely what the field requires. However, again the difficult decision would have to be faced—what is to be taken out? There are just so many weeks in a semester and learning is a time-consuming process.

One possible developmental direction is the introduction of production codes in other classes, as, for example, is being done in the fall semester heat transfer and fuel management courses. Another possible alternative is to use the considerably simplified codes developed recently at VPI.[13] Whichever direction the evolution takes, feedback from industry and former students has convinced us that direct experience with design-type codes is presently an essential part of an undergraduate nuclear engineering education.

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12. L. C. RICHARDSON et al., "CONTEMPT, A Computer Program for Predicting the Containment Pressure-Temperature Response to a Loss-of-Coolant Accident," IDO-17220 (1967).
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3. A Graduate Training Program in Experimental Reactor Physics, *L. Holland (IEA-Brazil), S. Shalev (IAEA)*

In an effort to increase the number of nuclear engineers available for the rapidly developing Brazilian nuclear energy program, the Instituto de Energia Atômica in São Paulo offers a graduate program in nuclear engineering.[1] This is consistent with the policy of minimizing the dependence of the emergent Brazilian nuclear energy industry on foreign expertise. In contrast to countries with a more advanced nuclear program, Brazil must stimulate graduate engineers and physicists to "go nuclear" to satisfy future, rather than present needs. In this aspect, IEA offers the essential facilities necessary for an advanced training course and also a research program sufficiently demanding to retain trained personnel in the field until the industrial nuclear sector offers suitable employment opportunities. Theoretical subjects do not present a problem, particularly when given with the help of foreign specialists in cases where there is a lack of suitably qualified nationals. However, providing training in experimental techniques is less straightforward, and it may be that our experience will be of value to similar institutions in developing countries.

In addition to standard lecture courses in reactor physics, radiation detection, etc., our experimental graduate program consists of three main sections:

1. advanced laboratory in experimental techniques
2. regular and frequent seminars and discussion groups in which the students take turns in presenting material on a wide variety of topics
3. individual thesis topics.

The advanced laboratory makes use of facilities available in the IEA. Day-long experiments on the 2-MW swimming pool reactor include control rod calibration (period and rod drop), power measurement (neutron flux, N-16, and thermal balance), and temperature coefficient of reactivity. Experiments on reactor noise using a pseudo-random chopper and reactivity using a sealed-tube pulsed-neutron source are being prepared. The students also use a 400-keV Van de Graaff to study neutron production and detection, as well as thermal-neutron decay in moderators (pulsed-neutron technique). A 16-k on-line computer is used for data analysis, and the students are encouraged to prepare their own programs.

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The program GENFIT was specially prepared in BASIC for student use in curve fitting. The program solves the nonlinear least-squares problem in a completely general way, and all instructions pertaining to a particular function are relegated to a subroutine which is written by the user. The average student can define his own function, type the subroutine instructions, and obtain the least-squares fit (tabulated and plotted) in an hour or two.

The discussion group program has proved to be of considerable value. Students with different backgrounds, abilities, and experiences are mixed in a single group, which meets two or more times every week for two-hour sessions. The topics are apportioned well in advance to permit adequate preparation, and questions are asked on every aspect of the material. In this way, gaps in each participant's knowledge are revealed and corrected, and a rigid framework is provided as an encouragement for self-study.

In addition to the above program, each graduate student in experimental reactor physics must submit a thesis on his own research topic. The availability of equipment, adequate technical assistance, and sufficient suitably qualified supervisors are all serious problems in relatively new institutes in developing countries. Thesis topics in the IEA currently include activation analysis (oxygen in uranium and in steel), nondestructive fuel burnup measurements, reactivity determination using a pulsed-neutron source, flux measurements in the reactor core, nuclear material assay, design and construction of a subcritical assembly, and on-site analysis techniques for ores and minerals.

In summary, it has been shown that an adequate program in experimental reactor physics can be provided with a minimum of facilities and equipment. A high level is maintained in a limited number of subjects, perhaps at the expense of breadth and completeness of the program. However, we feel that our experience should act as encouragement to institutes in other developing countries to set up similar programs in experimental reactor physics.

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4. An Inter-University Technology Assessment Project, *Glenn A. Whan (U of New Mexico)*

It has been proposed that Plowshare technology might contribute to the extraction of natural gas from deep, tight gas-bearing strata in some areas where recovery may not be economically feasible by conventional means.[1–4] Commercial field development, however, offers major challenges to planners and policy-makers in industry and in all levels of government. In anticipation of considerable public debate as to benefits and costs associated with widespread commercialization, the Western Interstate Nuclear Board initiated an inter-university technology assessment project to develop a body of objective, independently derived information and guidelines for use by state policy organizations in planning and making decisions. Although the primary objective was to provide information that could serve as a basis for making safety and welfare decisions, the project was specifically designed to involve graduate and undergraduate students in interdisciplinary research on a real-world problem. It was also anticipated that the project might stimulate the initiation of other inter-university technology assessment studies by regional academic institutions and government agencies.

The project involved the participation of a broad-based steering committee as well as an interdisciplinary research team of faculty members and student assistants at the Universities of Colorado, New Mexico, Utah, and Wyoming, and at Colorado State University. Four major areas were studied: (a) assessment of Plowshare applications and their potential roles in optimum utilization of energy and material resources; (b) evaluations of hazards including seismic effects and the possible release of radioactivity; (c) studies of legal considerations embracing new federal and state laws and policies; and (d) assessment of methods for encouraging public participation in cost/benefit analyses.

The project research team included 14 faculty members and 12 student research assistants. Twelve research reports, covering a wide variety of subjects in the four major areas, were used as the information base for the final report.[5] As a sounding board, eight papers were presented at professional meetings and an additional five journal articles were published. Some of the faculty and students were involved concurrently in the proceedings of a lawsuit questioning a state's power to regulate federal Plowshare activities. The project provided nine research assistantships and five students received some academic credit.

In the final analysis, the principal objective of providing information for state-level decision making was realized. While the second "educational" objective, that of providing university student participation via research paper preparation, seminars, contacts with state and federal agencies, and interactions with various civic and public interest groups, was also attained, several difficulties were encountered. Less undergraduate student participation than desired was obtained, due primarily to inflexible curricula and time requirements committed to undergraduate course work. Also, adequate communication and exchange of ideas among the students on the interdisciplinary research teams proved to be difficult to achieve because of the great distances between the five universities in four states.

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3. "Project Rio Blanco Definition Plan, Vol. I, Project Description," PNE-RB-16, CER Geonuclear Corporation (Feb. 1972).

4. "Project Wagon Wheel—Technical Studies Report No. 2," PNE-WW-13, El Paso Natural Gas Company (Oct. 1972).

5. G. A. WHAN, "Final Report—Implications to State Governments," WINB Plowshare Technology Assessment Project (Sep. 1973).

5. Fission Spectrum Calculations in Slab Geometries, *J. C. Courtney, D. S. Ambuehl (La State Univ)*

To increase the effectiveness of our radiation safety courses, we are increasing the emphasis on digital computer analyses. Ideally, the codes used in instruction should have straightforward logic and relatively simple input. The method of computation should be clearly presented, and the results of the calculation should be reasonable.